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CASE REPORT

A movable finger prosthesis: A case report

Naina Swarup, BDS[1], Omkar Shetty, MDS[1], Gaurang Mistry, MDS[1], Shikhar Singh, MS[2], Pratik Shah, BDS[3]

[1]Department of Prosthodontics, DY Patil University, School of Dentistry, Mumbai, Maharashtra, India.
[2]Department of Orthopedics, DY Patil Medical College, Mumbai, Maharashtra, India.
[3]Department of Conservative and Endodontics, DY Patil University, School of Dentistry, Mumbai, Maharashtra, India.

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Corresponding Author:

Dr. Naina Swarup
Department of Prosthodontics, DY Patil University, School of Dentistry.
B4 New Trishul, Marol Maroshi road, Andheri East, Mumbai, Maharashtra, India.

Phone number:+919892615358
email: nainaswarup@gmail.com

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ABSTRACT

I cried that I had no rings, till I saw someone who had no fingers. Whether the traumatic loss of limbs or fingers is due to war, congenital malformations, systemic diseases (diabetes), industrial, domestic or vehicular accident, or amputation, it leaves the individual with a long-lasting emotional scar from the disfigurement. We as prosthodontists have the skillset to change a patient's life by making a prosthesis that would enhance a patients' physical and psychological well-being. Through time, emphasis has been made on replacing a lost digit for aesthetic purposes but function is equally important, if not more. Movement of a finger using the movement of the patient's own hand may provide the patient with adequate movement to carry out his or her daily activities. In this age of digitalization, the use of impression materials is slowly but steadily reducing. The movable finger prosthesis described in this article eliminates the need for using any impression material as well as shows the use of 3D printing to make a functional prosthesis. (*Int J Maxillofac Prosthetics 2019;1:14-19*)

INTRODUCTION

Finger and partial finger amputations are some of the most frequently encountered forms of partial hand loss.[1] Trauma is the most common cause of these amputations.[2] "Amputation", derived from the Latin word "amputare "(to excise, to cut out), has been defined as the "removal of part or all of a body part enclosed by skin" (Online Medical Dictionary). Until the eighteenth century, with the exception of Pare, few physicians gave thought to the condition of the amputation stump for prosthetic appliance.[3] The introduction of antiseptics by Lister allowed surgeons to take more time to produce viable stumps capable of supporting prosthetics.[4]

Amputation causes devastating physical, psychosocial and economic damage to an individual.[5] Beasley has noted that individuals who keep their hands hidden inside pockets due to embarrassment over appearance are as functionally disabled as a forequarter (scapulothoracic) amputee.[6] Despite the fact that many advancements have occurred in surgical reconstruction techniques,[7] this type of surgery is not practical nor is it successful or indicated in many patients with partial finger amputations. The role of a prosthodontist in this case is to replace what's missing, the missing finger, by the most life like replica possible. Prosthetic rehabilitation of these patients has been shown to help psychosocial aspects by providing increased grip strength and reduced hypersensitivity and pain.[8, 9]

According to the information from National Centre for Health Statistics, trauma alone accounts for >75% of the reason for limb amputation. It was also reported that the most common among such amputations is partial hand amputation with loss of one or more fingers. Hand injuries count for 1/3 of all injuries at work, 1/3 of chronic injuries, 1/4 of lost working time, and 1/5 of permanent disability.[10]

Allen's classification is commonly used to describe

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the level of amputation for fingertip amputations. Type 1 injuries are those involving the pulp only. Type 2 injuries consist of injury to the pulp and nail bed. Type 3 injuries include distal phalangeal fracture with associated pulp and nail loss. Type 4 injuries involve the lunula, distal phalanx, pulp and nail loss.[11]

The basic goal is to restore a pinch or vise mechanism that works effectively with normal tactile sensation. A precisely fitting finger prosthesis may transmit both pressure and position sense needed for automatic control for a finger but may not provide for the required mobility.

Prosthetic devices for the hand are classified as total or partial hand prostheses. In turn, total prostheses can be divided into actively or passively adjustable types.[2] Active Prosthesis help with functions and are designed for work, sports and hobbies where a residual hand or general prosthesis could be damaged or wouldn't work as needed. Passive prostheses help provide function for everyday life but do not have active grasp and release. Partial hand prostheses are all passive, but in general are more successful than total hand prostheses in improving mechanical function. They can at times even benefit the bilaterally injured. They are useful to restore length to opposing parts and enhancing physical capability.

According to David J. Magee's functional assessment[12] of the fingers, each finger has a different function and its loss will have different consequences to the patient: "The thumb is the most important digit due to its relation with the other digits with mobility and force, its loss can affect the hand greatly. The loss of thumb function affects about 40 % -50 % of the hand functioning. The index finger is the second most important digit because of its musculature, its strength and interaction with the thumb. Its loss will affect the lateral and pulp-to-pulp pinch and power grip. The loss of the index function accounts for about 20 %. In flexion the middle finger is the strongest and is important for precision and power grips. The loss of the middle finger function accounts for 20%. The ring finger has the least functional role in the hand and accounts for 10% of loss in function. The little finger has great peripheral positioning and greatly enhances the power grip. Also, the little finger affects the capacity of the hand and holds objects against the hypothenar eminence. The little finger accounts for 10% loss in function."

Loss of the hand accounts for about 90% loss of upper limb function. When a finger is restored, it generally restores the functional efficiency to a total of 100%.

The importance of aesthetics over function varies from individual to individual. Prostheses available for the patients are generally aesthetic and patients may opt for those but they may be short-lived since the function is compromised. Since our patient needed to be able to perform functions and aesthetics was a secondary requirement, we opted for a functional prosthesis covered by a silicon sleeve in the following clinical report.

CASE REPORT

A 35-year-old male patient presented to the Department of Prosthodontics and Implantology with partially amputated fingers. The distal phalange of his left hand middle and ring fingers were accidentally amputated (Fig 1). The right hand was the patient's dominant hand but due to his profession, he wished for some mobility in his left hand as well. On closer examination, and palpation, the stumps were smooth with no hard prominences. The patient had no complains of pain, tenderness or paraesthesia and normal proprioception (ICF: b260 Proprioceptive function). But since the stumps were close to the phalangeal joint, there was a loss of movement at the joint (ICF: b7100 Mobility of a single joint). The diagnosis by ICD codes was S68.613A and S68.615A.

Due to his profession as a gardener and a complete inability to achieve any sort of movement with his left hand (ICF: d440 Fine hand use), the patient requested a prosthesis that would be functional. Functional assessment[12] of the hand was carried out which showed a total of 15% loss of function due to the deformity.

Digital impressions were made using an intra oral digital scanner (3 shape Trios) since it was less time consuming and provided more accurate details when compared to conventional techniques[13] (Vid 1). Care had to be taken by applying adequate amounts of dusting powder on the surface of the hand to get a matt surface. Since it was an intraoral scanner, it had 3 settings- maxillary, mandibular and occlusion settings. The scan of the middle finger was made in the mandibular arch setting, the ring finger in the maxillary arch setting, and the interdigital impression was recorded under the occlusal setting of the scanner to achieve adequate height of the stump (Vid 2).

The 3D scanned data was converted to an STL file to digitally design the prosthesis (Fig 2). Scaled Photographs of the contralateral hand were used to assess the length of the fingers. The rigid parts were 3D printed in Polylactic acid (PLA) and the flexible parts in thermoplastic elastomer (TPE) using rapid prototyping additive manufacturing. The 3D printed components then needed to be post processed to ensure the removal of spicules and/or irregularities and the patency of the holes of the printed component was verified, after which they were assembled together. The printed models were

Fig 1. Patients left hand showing partial amputation of the middle and the ring finger.

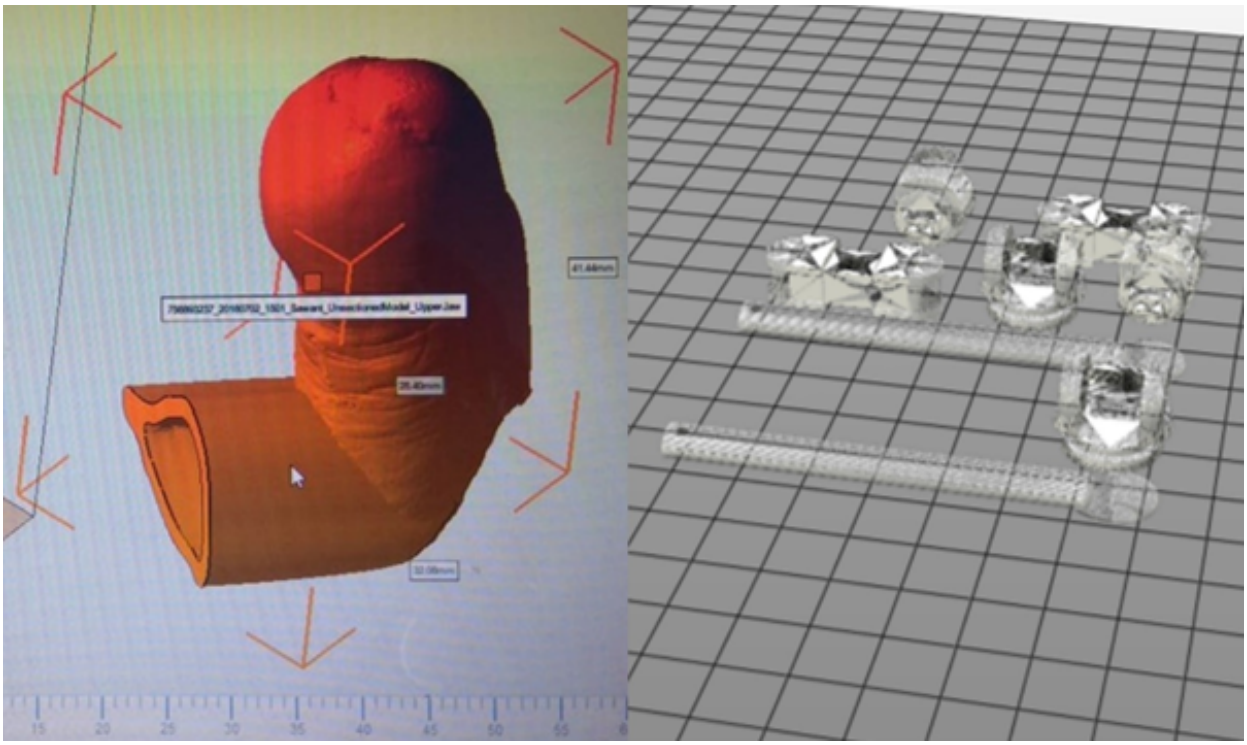


Fig 2. The STL of the finger and the designed components of the prosthesis.

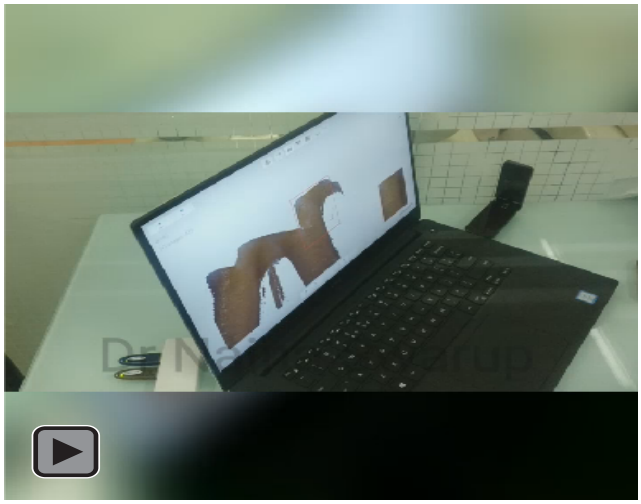
post processed and care was taken to ensure no excessive reduction was done and at the same time the holes were maintained patent for the screws so as to make the movement as smooth as possible.

The rigid and flexible components were connected using elastic cords comprising of one or more elastic strands forming a core covered in a woven cotton sheath and nylon threads to help facilitate movement. The joint assembly of the prosthesis replicated a joint and permitted movement around that joint. Once the assembly was completed, its movement was evaluated before trying the prosthesis on the patient (Vid 3). The prosthesis had movement in the distal phalangeal joint thanks to the tension created on the nylon threads.

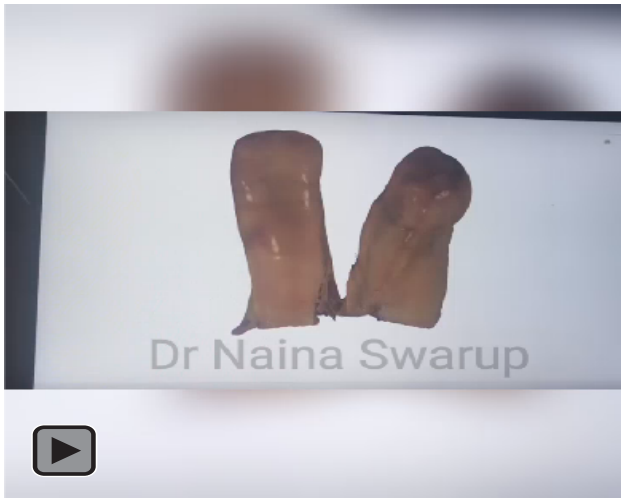
The prosthesis was tried on the patient's hand to evaluate the fit and length and compare it with that of the contralateral hand. The movement of the prosthesis was assessed and evaluated by making the patient voluntarily move his fingers (ICF: b760 Control of voluntary movement functions) (Vid 4) and lift a bottle (ICF: d430 Lifting and carrying objects) (Fig 3).

The design was made to permit maximum movement possible without any obstructions. A silicon sleeve was given to cover the phalangeal portion of the prosthesis to make it look natural (Fig 4). The silicon sleeve was thinned down in the areas requiring movement so as to not impair or compromise the movements. Restoration of these fingers gave the patient a functional assessment score of 95%.

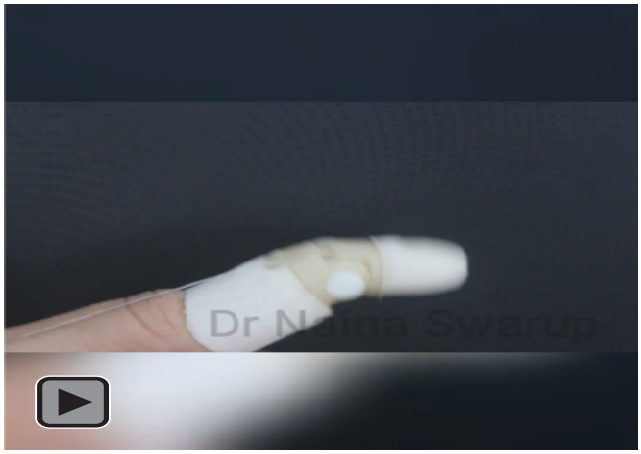
The patient could hold a bottle with adequate strength as we utilized his own hand strength to control the voluntary movements of the fingers (ICF: b760 Control of voluntary movement functions). This strength permitted him to hold scissors as well so as to carry out his day to day activities (ICF: d230 Carrying out daily routine).



Vid 1. Digital Impression being made by an intra oral scanner.



Vid 2. Completed digital impression.



Vid 3. Movement of the connected assembly being checked.

Vid 4. Final movement of the assembly by the patient.

Fig 3. The prosthesis on the hand and in function- without the silicon sleeve.

Fig 4. Final Prosthesis covered by the silicon sleeve.

DISCUSSION

Before the prosthetic restoration of an amputee, the functional requirements of the individual and management options must be discussed with the patient. A complete hand examination should be performed, estimating the amount of injury to the fingertip, angles and levels of amputation, loss of tissue, involvement of nail, involvement of other fingers, neurovascular involvement, and function of the hand. After assessing the fingertip injury, a treatment plan should be formulated. Management starts with history elicited from the patient regarding the nature of the injury, age, hand dominance, occupation, recreational activities (including playing sports and musical instruments), previous history of hand injuries or problems and other systemic diseases that affect wound healing.[14]

Digitalization is the latest development in prosthodontics. The patient was a gardener by profession and required as much function as possible. The long extensor tendons of the hand were duplicated by the nylon thread and a tension was applied by this. The interosseous and lumbrical muscles pull the finger back. The movement though, was in a stepper fashion and attempts could be made to convert them to servo movements. Stepper movements occur in series increments or steps whereas servo movements run faster and more smoothly.

Despite the advances in microsurgical techniques, reconstruction of amputated digits for a number of patients may not be successful and they can be more benefited with passive prostheses.[11]

CONCLUSION

The major advantage in this sort of prosthesis is the increase in function and its cost effectiveness. The loss of a finger need not be permanent. It is in our control to lend a hand to heal a hand.

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